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ILS/MLS Collocation Tests at Miami/Tamiami, Florida Airport

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16. Abstract

A series of tests were performed by the Federal Aviation Administration (FAA) Technical Center at the Miami/Tamiami, Florida, Airport to verify the guidance material contained in the proposed amendments to Attachment G to Part I of the International Civil Aviation Organization (ICAO) Annex 10. A mock-up of the Technical Center's Test Bed Microwave Landing System (MLS) was collocated with the category I instrument landing system (ILS) on runway 9R. Several engineering flight tests were flown with ILS data collected and analyzed. These results were later verified by actually installing the MLS test bed at one of the locations used for the mockup tests. The results indicate that the proposed guidelines are adequate as published, but several items should be considered when implementing these guidelines. These items are presented as recommendations.

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Air Traffic personnel from Tamiami Tower and Miami Approach Control

Dade County Airport Department

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

A series of tests were performed at the Miami/Tamiami, Florida, Airport to verify the guidance material contained in the proposed amendments to Attachment G to Part I of the International Civil Aviation Organization (ICAO) Annex 10. A mockup of the Technical Center's Test Bed Microwave Landing System (MLS) was collocated with the category I instrument landing system (ILS) on runway 9R. Several engineering flight tests were flown with ILS data collected and analyzed. The results indicate that the proposed guidelines are adequate as published, but several items should be considered when implementing these guidelines. These items are presented as recommendations.

BACKGROUND

During the month of March 1989, a series of tests were performed at the Miami/Tamiami, Florida, Airport to verify the guidance material contained in the proposed amendments to Attachment G to Part I of the International Civil Aviation Organization (ICAO) Annex 10. The proposed amendment provides guidance for siting an Microwave Landing System (MLS) to be collocated with an existing instrument landing system (ILS) and can be found in the ICAO All Weather Operations Panel (AWOP) Working Paper (WP) 561. This report details these tests that were the initial part of a series of tests (which were also performed at Miami/Tamiami) and included ILS/MLS comparisons as well as a demonstration of MLS Area Navigation (RNAV) capability. The results of these additional tests are covered in other reports.

Miami/Tamiami Airport is located approximately 5 miles southwest of Miami and is operated by the Dade County Airport Department. The airport is a general aviation airport with very high traffic volume and has extremely flat terrain. The airport has three runways: a pair of parallel 5,000 foot runways (9-27 left and right), and a 4,000 foot diagonal runway (13-31). The ILS services runway 9R and consists of an eight-element log periodic localizer array and a null reference glide slope array. The ILS is a category 1 commissioned facility. Figure 1 is a drawing showing the ILS siting.

TEST PROCEDURES

A mockup of the Bendix-built Federal Aviation Administration (FAA) Technical Center Test Bed MLS 2° beamwidth azimuth and 1.5° beamwidth elevation stations were designed and fabricated at the Technical Center and transported to Tamiami. The mockups were framed using a 1-1/4 inch poly vinyl chloride (PVC) pipe covered with 1/2 inch grid hardware cloth and were exact physical representations of the actual system. The Test Bed MLS was used because this system was to be installed where the mockup had been to perform the above mentioned ILS/MLS comparison tests and MLS RNAV demonstration. In addition, the Test Bed MLS is physically larger, especially the elevation, than other MLS's. This should have given a "worst case" situation as far as collocation was concerned. Figure 2 is a drawing of the Test Bed MLS azimuth and elevation stations.

All of the data collected were airborne data using a fully instrumented Convair 580 (CV-580). A Bendix RNA-34AF navigation receiver was used to collect the ILS data. This receiver outputs both digital and analog information. The aircraft tracking was performed using a Warren Knight balloon theodolite and a JC Air frequency modulation (FM) radio telemetric theodolite (RTT). Distance measuring equipment (DME) ranging data, for reference information only, were collected using the Biscayne Bay collocated very high frequency omni-directional radio range (VOR) and tactical air navigation (TACAN) (VORTAC). Both analog (strip chart recorder) and digital (Kennedy 9-track recorder) data were collected. The analog data were used for real time "quick look" information, while the digital data were processed post flight and is used in this report.

Two sites were chosen to be tested at both the localizer and the glide slope. At the localizer, the test azimuth sites were on the runway centerline extended at distances of 100 feet and 200 feet in front of the localizer array. The proposed appendix J states that the azimuth should be sited no closer than 100 feet in front of the localizer. The azimuth/localizer test sites are shown in figure 3. For elevation/glide slope collocation, the proposed guidance material states that the elevation antenna should be sited outside the 10-decible (dB) point of the horizontal pattern of the glide slope array, or outside of a line from the base of the glide slope antenna to the runway centerline at threshold, whichever is greater. An additional stipulation is that the runway crossing heights should coincide within 1 meter. The two sites selected for the elevation antenna are shown in figure 4. The site closest to the runway is outside the line from the base of the glide slope antenna to the threshold on centerline, and is 145 feet forward of the glide slope and 44 feet from a line from the glide slope, parallel to the runway. The site farthest from the runway is outside the 10 dB point, and is 221 feet forward of the glide slope antenna and 79 feet from a line from the glide slope, parallel to the runway. In addition, the second site was placed far enough forward so as to not interfere with the glide slope field monitor if it were used.

The localizer tests were performed by first flying the ILS system in its normal configuration with no MLS mockup in place. This is referred to as the clean configuration. The mockup was then erected at the 100-foot point and localizer data were again collected. This procedure was repeated with the mockup at the 200-foot point. Each set of localizer data consisted of six runs: two runs were partial orbits to measure the course width, two were partial orbits to check clearances, and two were approaches to check course structure.

Testing at the glide slope was also performed in a clean configuration followed by erecting the mockup at each of the two test sites. Each of the three sets of glide slope data consisted of four runs: two runs were constant altitude centerline radials to measure the course width and two runs were approaches to measure course structure.

RESULTS AND ANALYSIS

The data indicate that the azimuth station at either of the tested locations does not effect the localizer course, but does have some minimal effect on the course width and clearances. This finding tends to support previous testing that indicated that objects placed symmetrically about the centerline of the localizer will have minimal effect on the course structure. Figure 5 is the localizer measured in a clean configuration. Little, if any, difference can be seen when these data are compared to figure 6 (mockup at 100 feet), figure 7 (mockup at 200 feet), and figure 8 (azimuth station at 200 feet). The high frequency deviations in figure 8 that appear at 4 and 6 miles are caused by overflights. Table 1 shows the results of the course width and clearance runs. The course width shown is the average of the two runs, while the clearance is the minimum recorded for the two runs. All of the data are within tolerance, but the clearance data with the mockup at 100 feet are very close to the tolerance limit. A second run in this configuration indicated clearances of over 200 microamps.

TABLE 1. LOCALIZER WIDTH AND CLEARANCE RESULTS

Condition	Width	Minimum Clearance	Clearance Tolerance
Clean	6.25°	217 microamps fly left	150 microamps
Mock up at 100 feet	6.40°	150 microamps fly left	150 microamps
Mock up at 200 feet	6.25°	206 microamps fly left	150 microamps
AZ antenna at 200 feet	6.00°	228 microamps fly left	150 microamps

The course width measurements at the glide slope were unaffected by the location of the mockup. When the elevation station was installed at position 1, the measurements indicated a slighter sharper (0.05°) course width, but these data were collected 2 weeks later and the system characteristics may have changed slightly over time. The glide slope course structure data are presented in figures 9 through 12. Figure 9 (clean configuration) and figure 11 (mockup at position 2) are similar and it appears that the MLS elevation antenna does not affect the glide slope if it is not sited between the glide slope and the aircraft. Figure 10 (mockup at position 1) is similar to the figures 9 and 11 except for a slight increase in error during the last 1/10 of a mile. Figure 12 (elevation station at position 1) shows the same trends. This increased error apparently results from the aircraft receiving reflections from the elevation station. At the end of these runs the aircraft position is approximately 50 feet above the threshold, and there may have been some line of sight interaction between the glide slope signal and the MLS elevation station. However, since this was a category I ILS, the signal was more than adequate down to the 200-foot minimums.

CONCLUSIONS

The Miami/Tamiami Airport (where the tests were performed) is an almost perfect instrument landing system (ILS) site with flat terrain and few obstructions. Because of this, the ILS had no unusual or marginal characteristics, even though it was only a category I installation. The results of these tests indicate that the proposed collocation guidelines are adequate as published, but several items should be considered when implementing these guidelines. These items are covered in the recommendations section of this report.

RECOMMENDATIONS

1. Although this was an ideal instrument landing system (ILS) site, some degradation was noted in the localizer clearances when the azimuth was installed at the minimum distance recommended in the proposed guidelines. It is recommended that the Microwave Landing System (MLS) azimuth antenna be installed as far forward of the localizer as space permits, and the 100-foot minimum distance for placement of the azimuth in front of the localizer should only be used as a last resort.

2. The MLS elevation station did not interfere with the category I operation of the glide slope at Tamiami. However, the data show that the glide slope course started to degrade as the aircraft passed just beyond threshold. Therefore, if

an MLS elevation station were to be collocated with a category II or category III glide slope, the elevation station should be sited as close to the runway as possible.

3. At Tamiami neither the localizer nor the glide slope systems used any external monitors. Collocating an MLS with an ILS with an external monitor could cause serious ILS monitoring problems. This may be particularly true with the glide slope.

4. A problem was discovered during the testing that does not appear to have been addressed in any document. During the second phase of testing, when the MLS stations were collocated with the ILS, a Federal Aviation Administration (FAA) flight check aircraft from Atlanta performed a periodic flight check on the Tamiami ILS. The system passed the flight check, but could not be returned to service because the ground technician could not verify the ILS operation at his ground check points because the MLS antennas interfered with line-of-sight reception of the ILS signals at his those locations. Therefore, even though the ILS passed the flight check, and the ILS signal-in-space was unaffected, the ILS had to be NOTAMED for the duration of our tests because the required ground tests could not be performed. It is recommended that the proposed guidelines be extended or additional ILS guidelines be written to include revised ILS ground check procedures to allow for line-of-sight reception of the ILS signals at the ground check points.

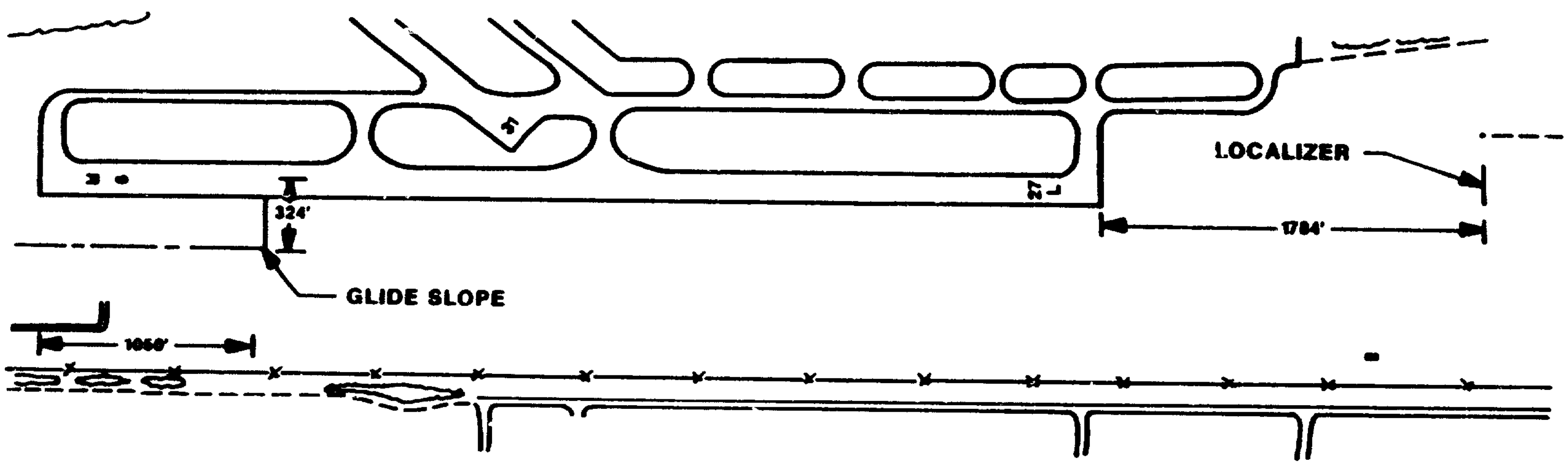
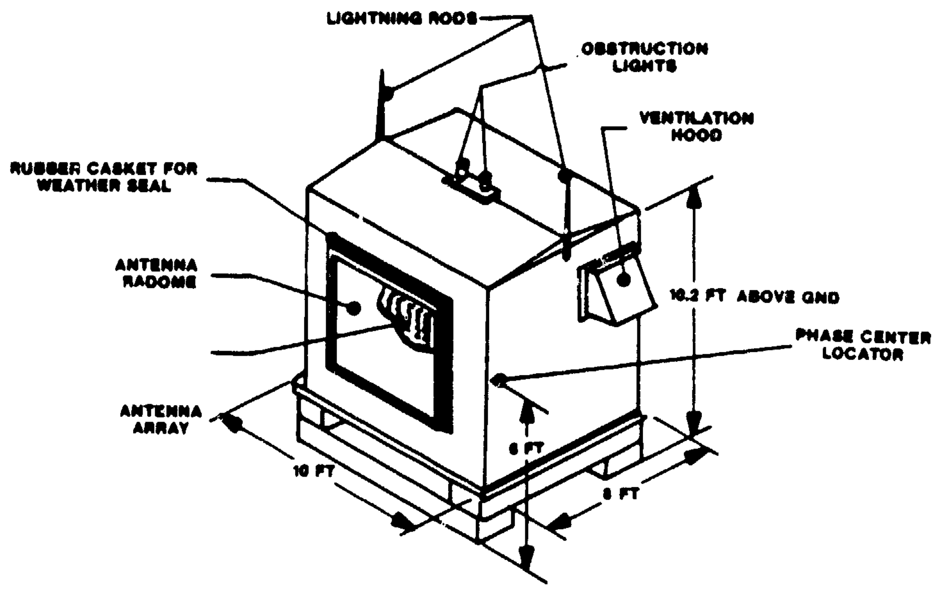


FIGURE 1. ILS SITING AT TAMIAMI AIRPORT



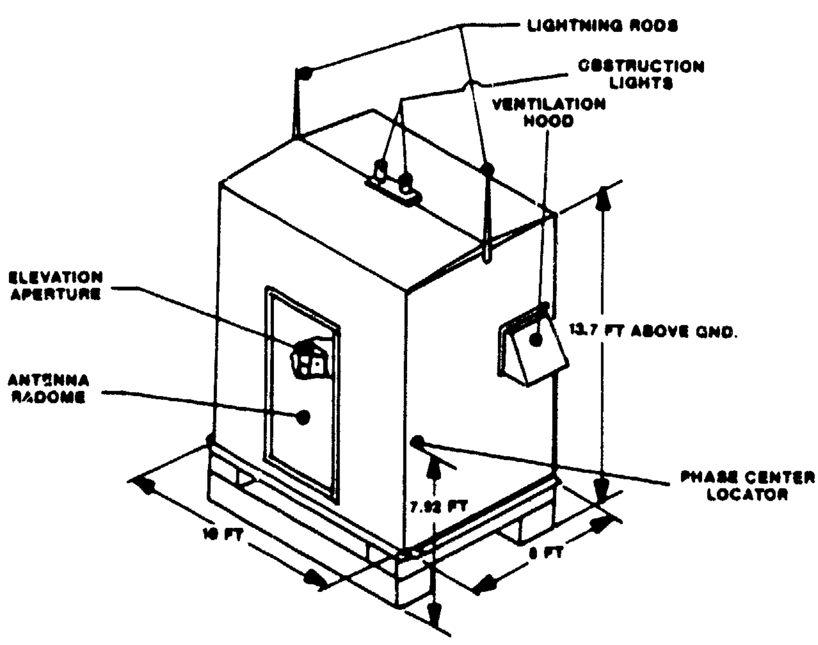


FIGURE 2. DRAWING OF MLS AZIMUTH AND ELEVATION STATIONS

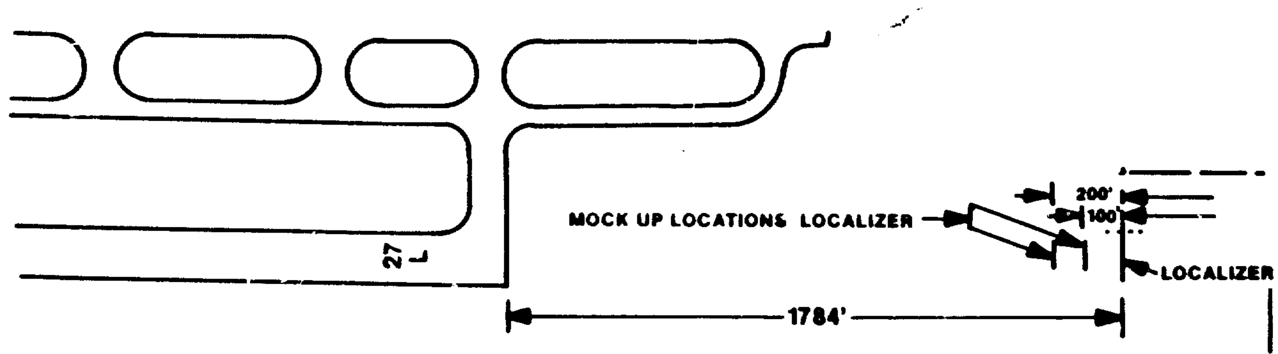


FIGURE 3. TEST SITES FOR AZIMUTH COLLOCATION

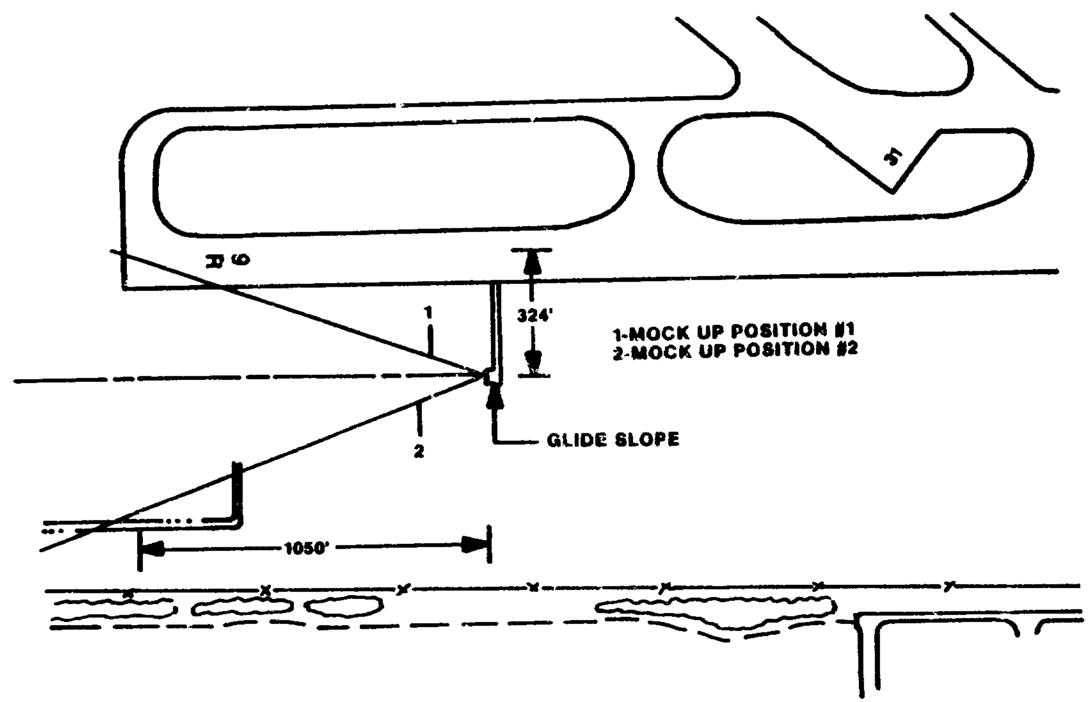


FIGURE 4. TEST SITES FOR ELEVATION COLLOCATION

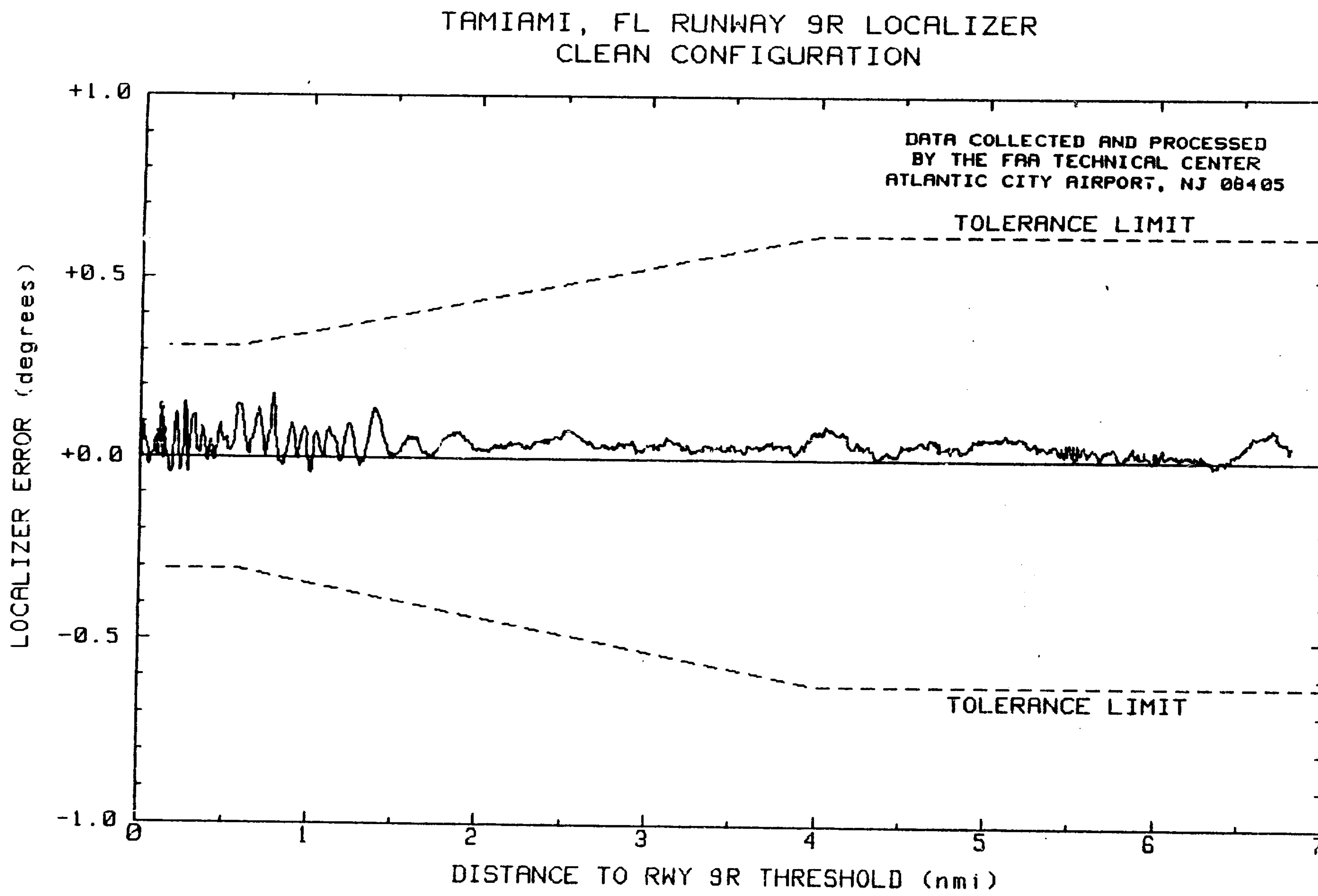


FIGURE 5. LOCALIZER DATA WITH CLEAN CONFIGURATION

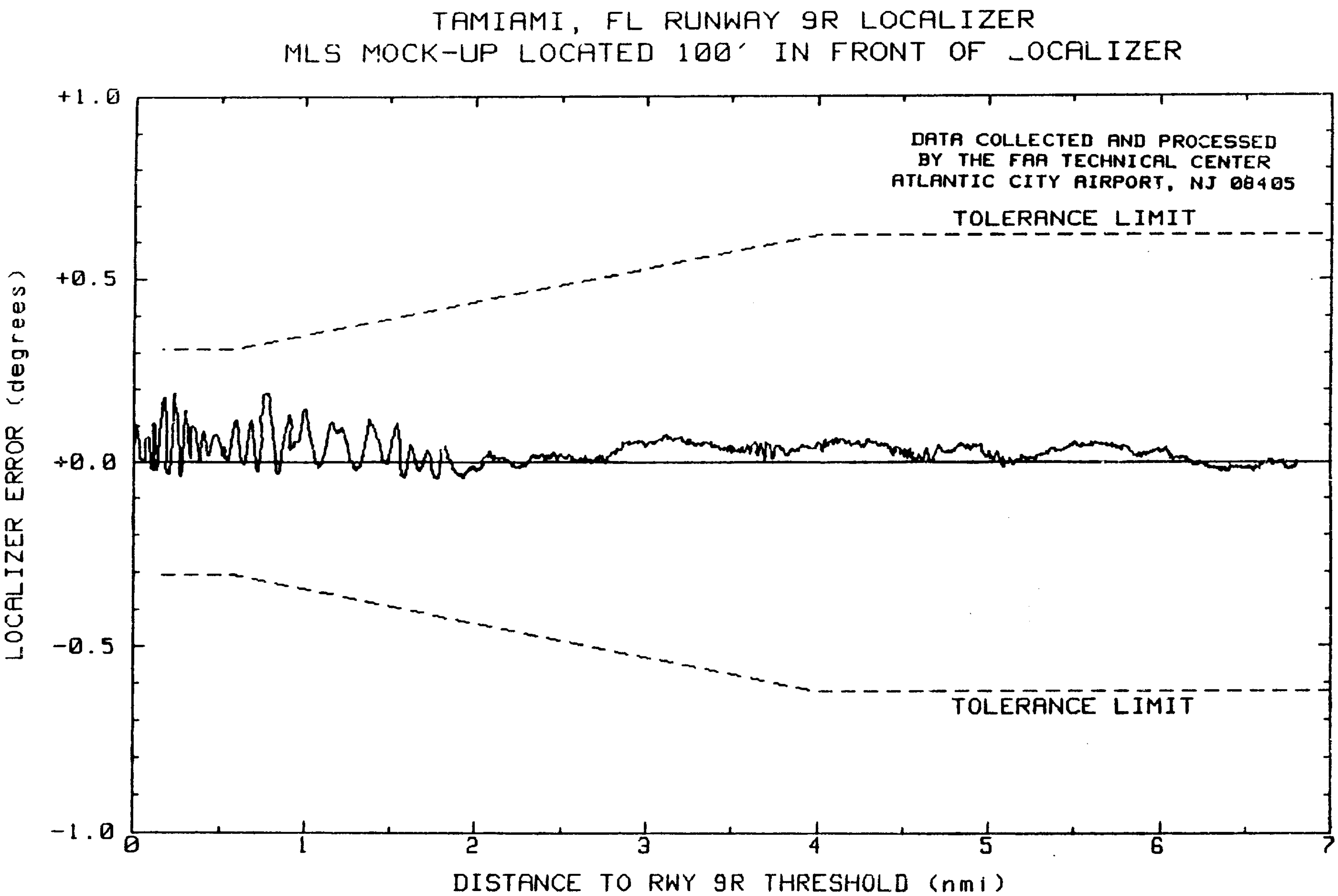


FIGURE 6. LOCALIZER DATA WITH MOCKUP 100 FEET IN FRONT OF LOCALIZER

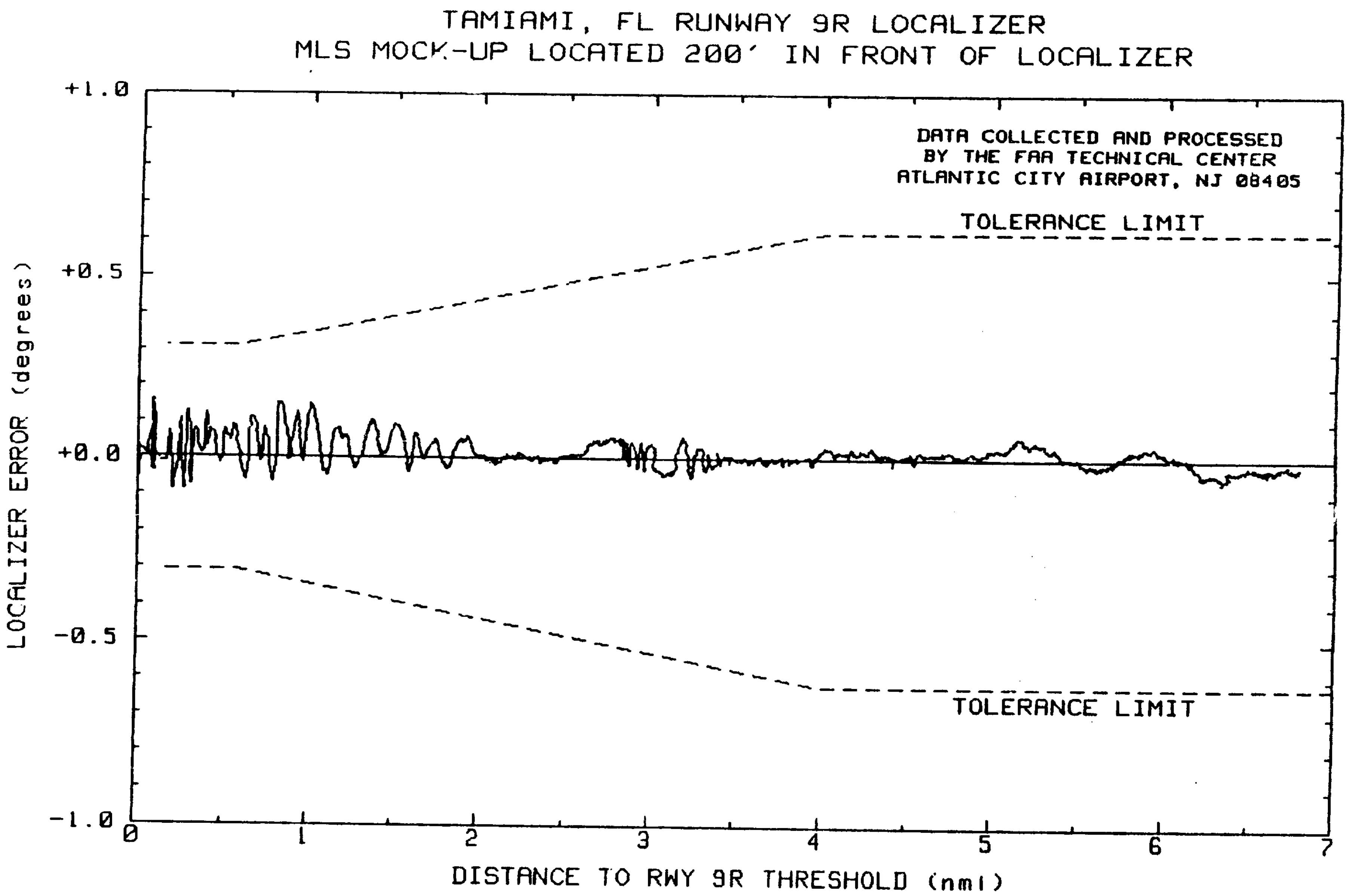


FIGURE 7. LOCALIZER DATA WITH MOCKUP 200 FEET IN FRONT OF LOCALIZER

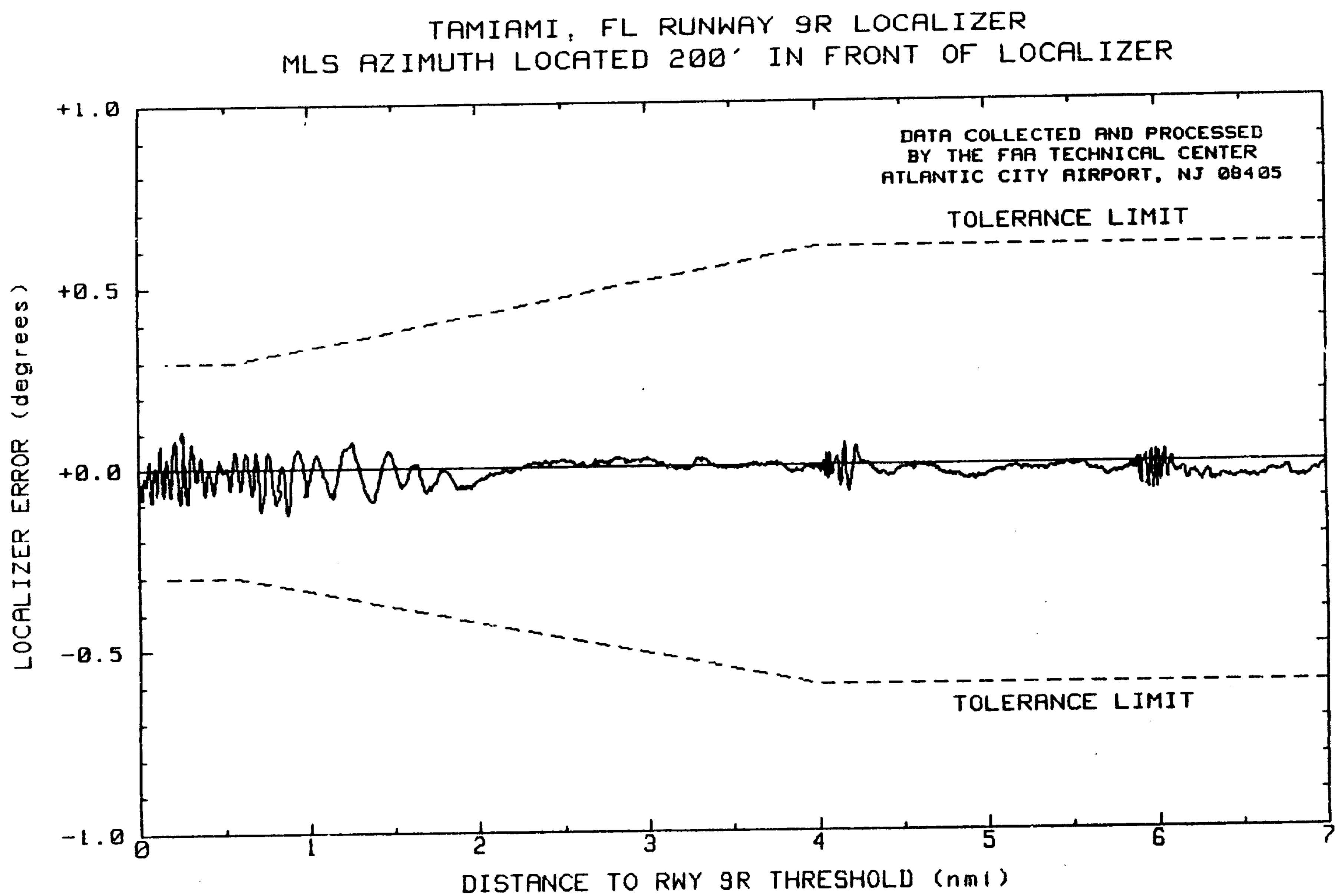


FIGURE 8. LOCALIZER DATA WITH AZIMUTH STATION 200 FEET IN FRONT OF LOCALIZER

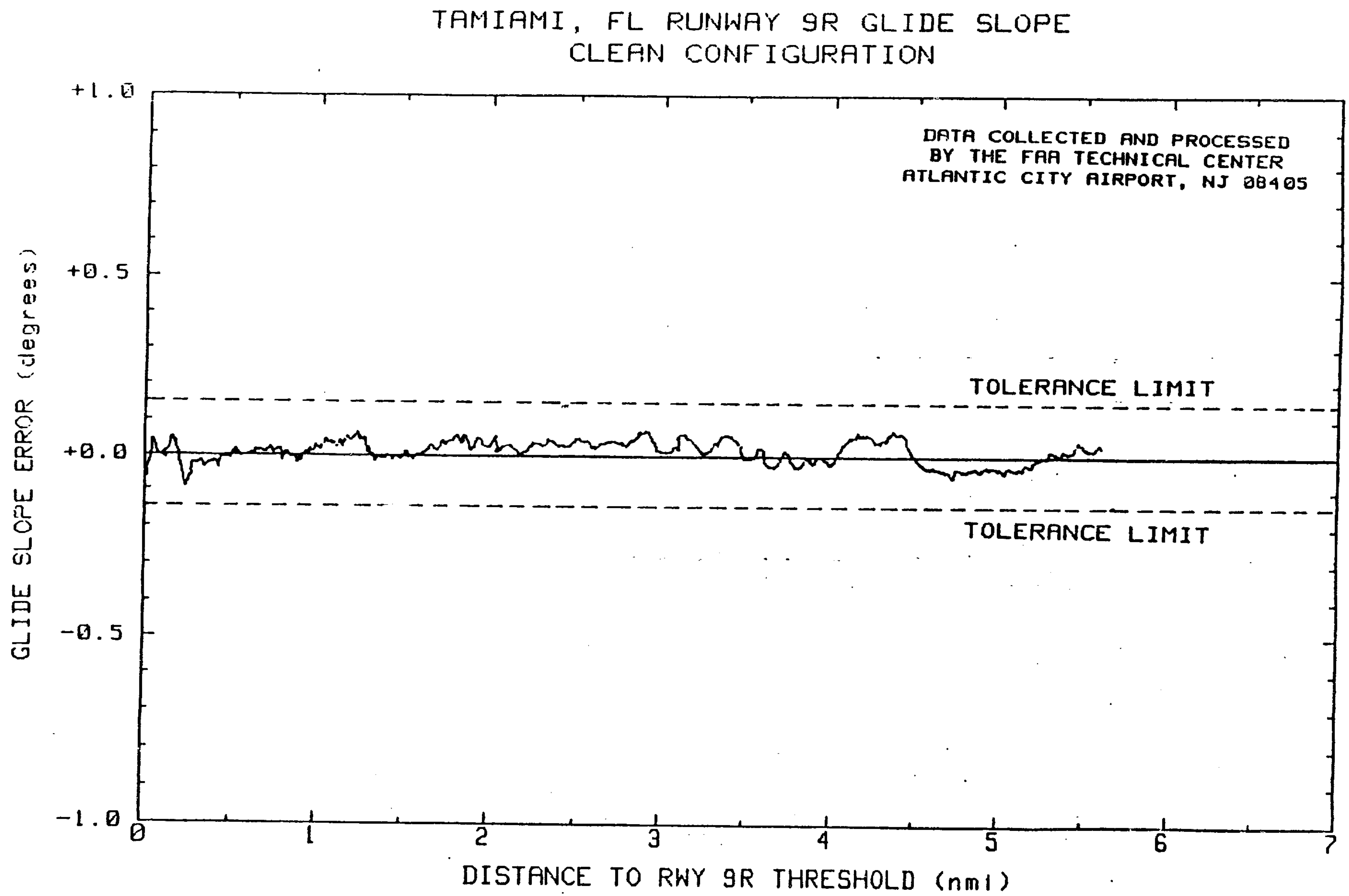


FIGURE 9. GLIDE SLOPE DATA WITH CLEAN CONFIGURATION

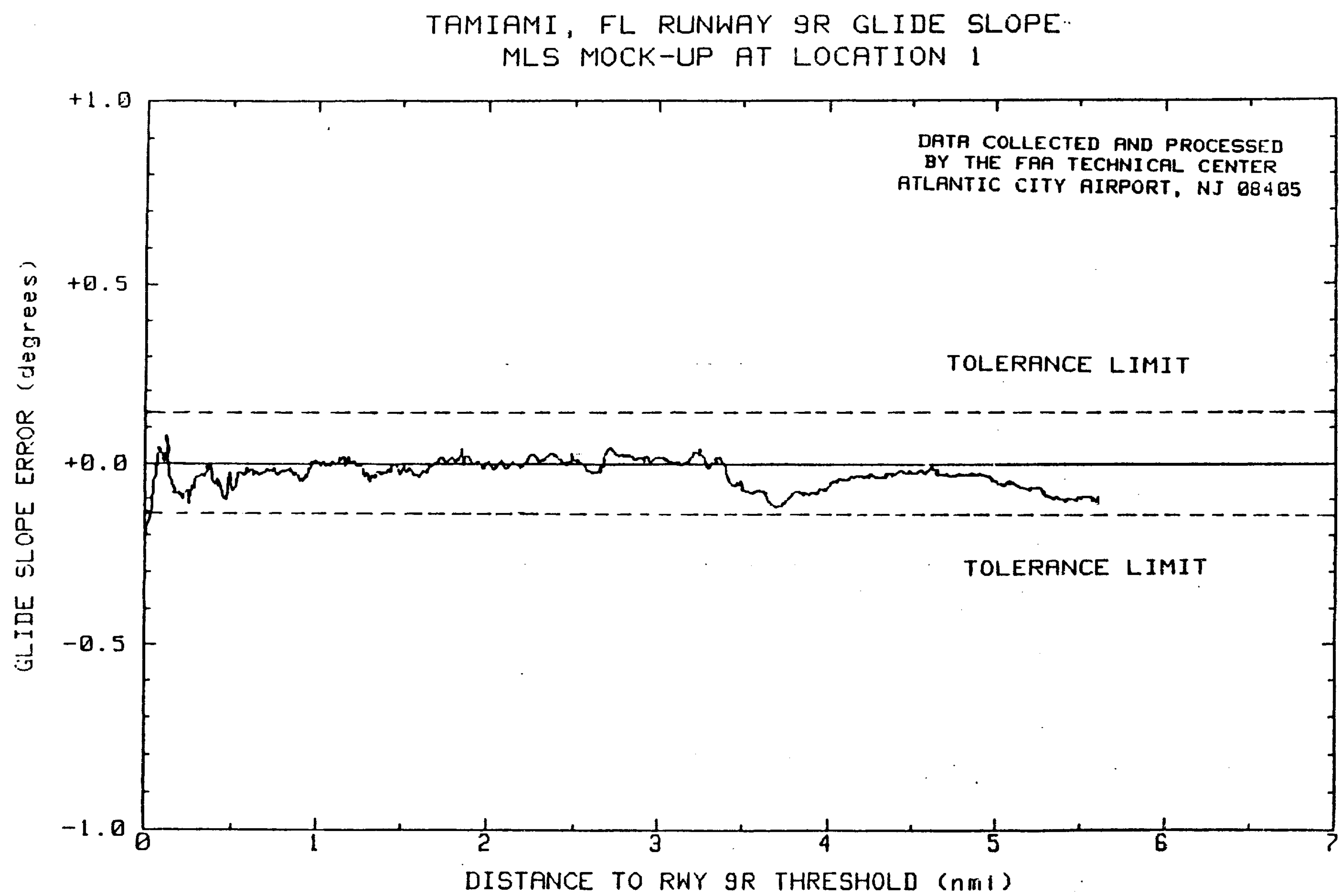


FIGURE 10. GLIDE SLOPE DATA WITH MOCKUP AT POSITION 1

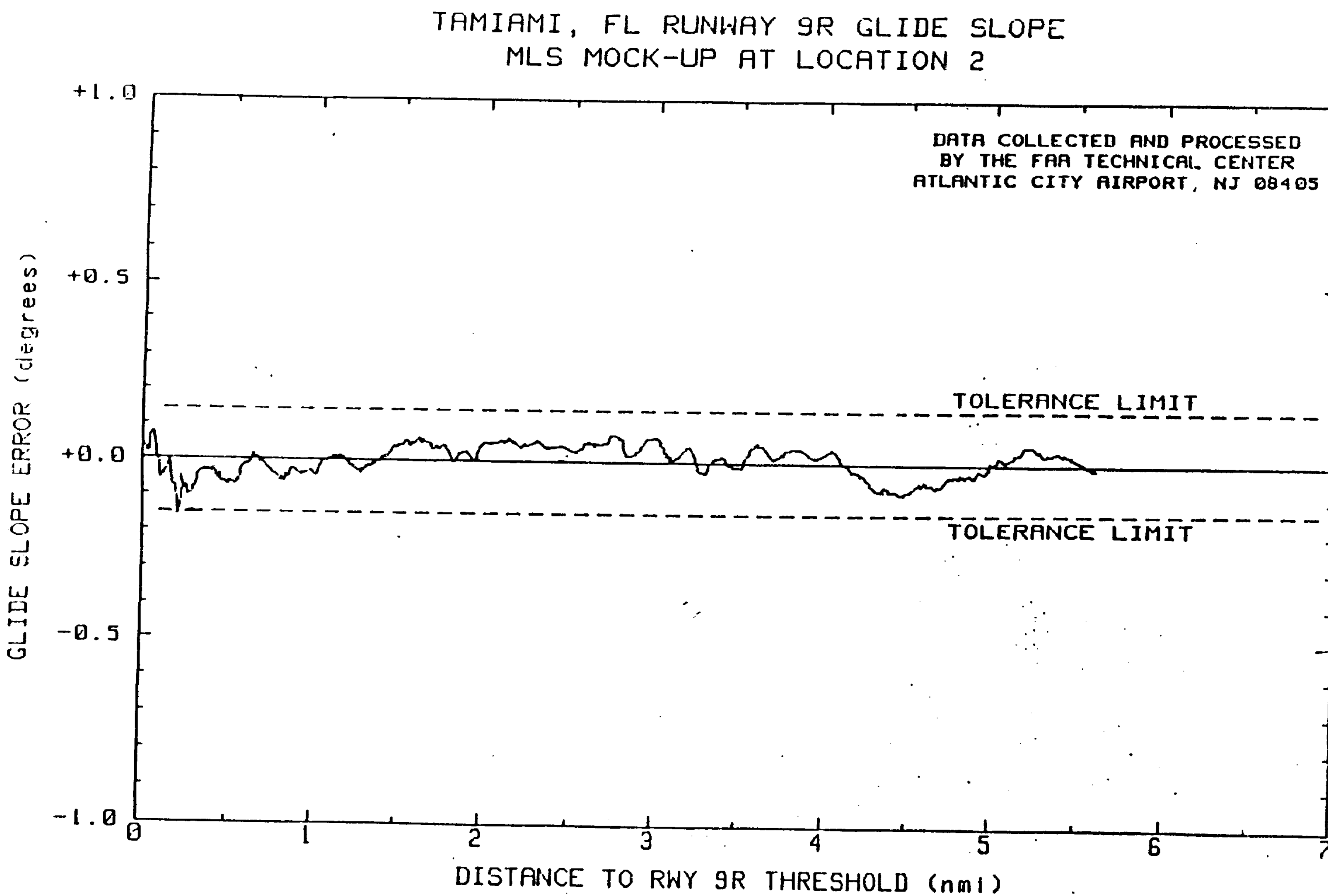


FIGURE 11. GLIDE SLOPE DATA WITH MOCKUP AT POSITION 2

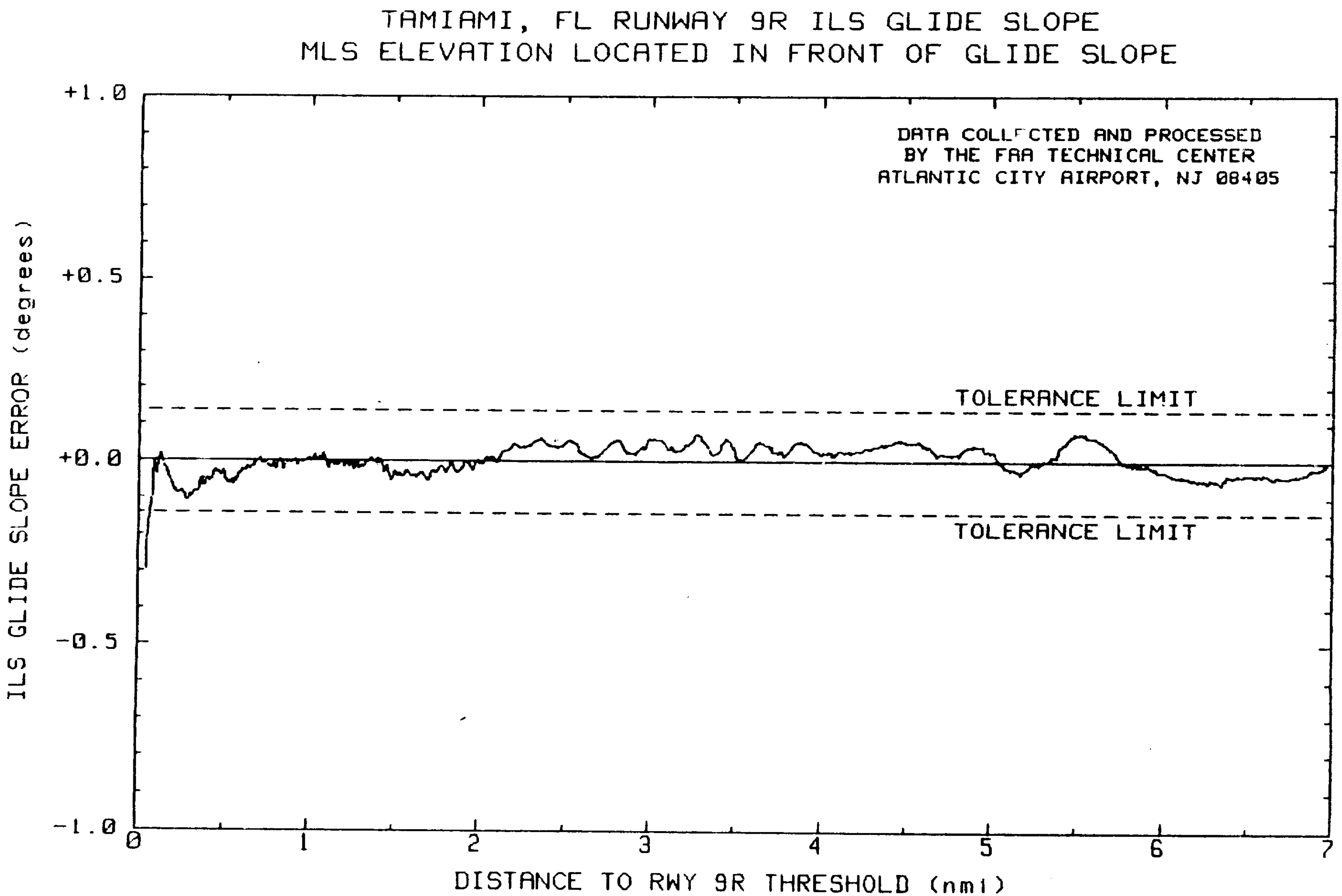


FIGURE 12. GLIDE SLOPE DATA WITH ELEVATION STATION AT POSITION 1